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AIR FORCE HUMAN RESOURCES LABORATORY

NAVIGATOR-OBSERVER SELECTION RESEARCH: DEVELOPMENT OF NEW AIR FORCE OFFICER QUALIFYING TEST NAVIGATOR-TECHNICAL COMPOSITE

By

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AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Toward the objective of improving selection of undergraduate navigator trainees, a large scale study was conducted to evaluate various experimental tests for possible use in a complete revision of the Air Force Officer Qualifying Test (AFOQT's) Navigator-Technical composite.

Forty-five noncognitive test scales and 17 experimental cognitive tests were administered to 507 students at the Officer Training School who subsequently entered undergraduate navigator training (UNT). Analyses of these data, along with AFOQT data, against training success indicated that, of the noncognitive materials, the only device

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with unique validity was the Personality Research Form; follow-up work with this is recommended. The experimental cognitive tests provided substantial improvements in prediction over that achieved with the present AFOQT. Content of a revised AFOQT Navigator-Technical composite is recommended.

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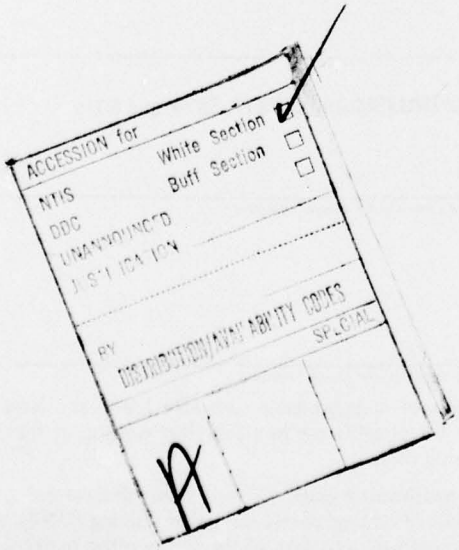

PREFACE

This work was performed under project 7719, Selection and Classification Technology; task 771912, Air Force Selection and Classification Technologies.

The study was planned and experimental data collection accomplished by Lt Col David Reinberg prior to his retirement; most of the later analysis was accomplished by Dr. Cecil Mullins. The author wishes to thank these individuals and Sgt Louis Kaluza whose assistance with detail work was available throughout most of the study.

TABLE OF CONTENTS

		Page
I.	Background and Introduction	5
II.	Approach	5
	Sample	5
	Predictors	5
	Criterion	5
III.	Results and Discussion	6
IV.	Recommendations	7
References		11
Appendix A:	Description of Tests	13

LIST OF TABLES

Table		Page
1	Means, Standard Deviations, and Validity Coefficients (N = 507)	8
2	Summary of Validities for UNT Pass/Fail (N = 507)	9
3	Prediction Models	10
4	Hypotheses	10
5	Summary of Hypothesis Test Results	11

NAVIGATOR-OBSERVER SELECTION RESEARCH: DEVELOPMENT OF NEW AIR FORCE OFFICER QUALIFYING TEST NAVIGATOR-TECHNICAL COMPOSITE

I. BACKGROUND AND INTRODUCTION

The Air Force Officer Qualifying Test (AFOQT) is revised periodically to avoid compromise and to incorporate improvements and changes dictated by an ongoing program of measurement research. Goal of the research described herein was to explore alternative measures to those currently comprising the Navigator-Technical composite of the AFOQT with a view toward thorough revision of that composite. Aims of such a revision were to enhance the composite's validity and to reduce, somewhat, its academic component with a view toward enhancement of compatibility with equal opportunity considerations.

For a considerable number of years, the Navigator-Technical components of the AFOQT have been fairly static, with form to form changes in specific items only; content areas were based on studies accomplished as much as 10 to 15 years ago, with validities established against the training curriculum as it existed at that time (see Miller, 1966).

More recently, a new curriculum for navigator training has been developed (see Semple et al., 1972a, 1972b, 1972c). Thus, a reassessment of selection test content was deemed appropriate. In the course of this study, a sizable battery of experimental measures were evaluated, along with the current AFOQT Navigator-Technical composite, as potential contributors to prediction of Navigator training success; the experimental battery used in the study was assembled by Lt Col David Reinberg, a senior navigator. Selection of material for the experimental battery was predicated on his understanding of the navigator's job, review of revisions in the training curriculum (accomplished during visits to Mather AFB, California), and careful considerations of the Navigator-Observer utilization field flying specialties study.

II. APPROACH

Sample

Experimental predictor information was collected during attendance at Officer Training School on a sample of 507 subjects who subsequently entered undergraduate navigator training (UNT). AFOQT scores were collected on these subjects from personnel record files. Training disposition data were collected from standard Air Force training disposition files for use as a criterion.

Predictors

Sixty-two experimental variables were included in this study; 45 of these may be characterized as noncognitive variables and include 16 scores from the Strong Vocational Interest Blank (SVIB), 3 scores from the Officer Biographical and Attitudinal Survey (OBAS), 1 score from the State-Trait Anxiety Inventory (STAI), 22 scores from the Personality Research Form (PRF), and 3 scores from the Navigator Attitudinal Reference Battery (NARB).

The 17 remaining cognitive measures are taken from an AFHRL developed reference test battery; 9 of these are characterized by at least some verbal loading while 8 were designed for minimal verbal loading. In addition, five AFOQT composite scores (Officer Quality, Pilot, Navigator-Technical, Verbal, and Quantitative) were available from operational Air Force files. The 62 experimental variables are described in Appendix A.

Criterion

The criterion was a dichotomous variable coded 1 if graduated from navigator school, 0 otherwise. Of the 507 subjects, 450 (88.8%) graduated. A criterion like this has characteristics which make it difficult to predict. First, the split (89%-11%) is very unfavorable—the simple mechanics of the statistical technique reduce the maximum Pearson correlation possible in such a situation. The zero-order correlations of predictors with such a dichotomy cannot exceed .60.

The problem is rather direct, practical, and straightforward—to find out whether an improvement in predictive efficiency can be obtained by reweighting the subtests that currently comprise the NT composite or by adding additional scores into computation of the composite from various subsets of the 62 available experimental test variables.

For each experimental variable and for the composites of the AFOQT, means, standard deviations, and biserial correlations with the pass/fail training outcome dichotomy were computed. In addition, intercorrelations of these variables, along with the criterion, were computed. Selected regression problems designed to assess unique added validity obtainable if selected variables, or subsets of

variables, were included in a Navigator-Technical composite were computed, and contributions to prediction were assessed via the F-statistic.

From these analyses, a subset of variables for inclusion in a revised AFOQT Navigator-Technical composite were selected, and validity of the revised composite was estimated.

Through the remainder of this report, individual scale validities and final Navigator-Technical composite validity estimates are reported in terms of biserial correlations; these assume that the dichotomous variable in the correlation is based on an underlying continuum. This would appear to be a reasonable assumption with respect to training success/failure. Multiple R's used in testing contributions to prediction of variable subsets are based on point-biserial correlations which are usually computed as part of the standard correlation and regression programs. These are lower values than the biserial correlations, but serve adequately when concern is with assessment of significant contributions.

III. RESULTS AND DISCUSSION

Outcomes of this study suggest that (a) some restructuring of the AFOQT Navigator-Technical composite, in the context of present AFOQT content, will yield improved prediction of Navigator training success, (b) augmentation of the Navigator-Technical composite with selected experimental cognitive tests results in highly significant improvement of predictive validity, and (c) the various noncognitive tests investigated do not significantly increase prediction of navigator training success. Major exception to this was found with the Personality Research Form; however, use of these materials in an Air Force test would require extensive developmental work to assure that the instrument's unique contribution is maintained.

Table 1 reports means, standard deviations, and biserial validities against UNT success for the various measures investigated in this study. A group of perceptual/psychomotor tests were administered experimentally to 77 of the cases in this study. Multiple correlation of these with UNT pass/fail was .65 (shrunken R was .37). These are covered under a separate work unit for which the technical report is in press (Hunter, Maurelli, & Thompson, 1977). Of the 45 noncognitive scales investigated, 7 achieved validities of statistical significance (3 at the .01 level of confidence and 4 at the .05 level). By contrast, of the 17 experimental cognitive measures investigated, all but one (Tools) achieved statistical significance (14 at the .01 level of confidence and 2 at the .05 level). Among the five AFOQT composites, highest validity was for the Quantitative composite (.28). Table 2 provides a summary of validity data by type of variable.

A series of different models for prediction of UNT success from these variable sets were computed and were used to test contributions to prediction. These models are described in Table 3. Table 4 states the hypotheses tested and the regression problems compared to test each one. Table 5 summarizes outcomes of the hypothesis testing.

From Hypothesis 1, it can be seen that modest improvement in UNT prediction can be achieved through use of AFOQT material not currently in the Navigator-Technical composite (R's are .11 vs. .19). Outcomes for hypothesis 4 indicate that still greater improvements in the composite can be achieved by including material from the experimental cognitive tests in the AFOQT (R's of .10 and .40).

With respect to noncognitive materials (Hypotheses 2, 3, 5, 6, 7, and 8), it can be seen that, with the exception of the Personality Research Form, the materials provide very little by way of unique predictive validity. This should not be interpreted as implying a lack of utility in predicting other criteria of Air Force interest (such as attitudes, motivation, service career retention); rather, the materials are of little use in predicting successful completion of UNT. The one exception to this observation, the Personality Research Form, is a carefully developed and edited commercial instrument which was designed to measure a large number of personality dimensions, principally for use in research studies. Its contribution to UNT prediction appears to be significant both in a statistical and a practical sense (its inclusion in a model with the cognitive test materials increased R from .40 to .46). However, it is not recommended at this time for inclusion in a revised Navigator-Technical composite for a couple of practical reasons. Proper arrangements with the publisher and author would be necessary before inclusion of portions of the material in an Air Force test booklet. Of even greater concern is the fact that some rather extensive analyses at the item level are needed to determine specifically which portions of the material are needed; once these determinations are made, very careful editing and tryout of an appropriate Air Force scale are necessary. It is entirely possible that administration of material from the form outside its present context could adversely affect its utility. Thus, considerable caution would be required to assure that an Air

Force scale based upon the material maintains the sound balance of the present instrument.

A subset of cognitive test materials was selected as most likely to represent the valid variance of the cognitive materials; thus, these constitute the most likely measures to constitute a revised AFOQT Navigator-Technical composite. Hypothesis 9 was designed to assess whether this subset of scales did, in fact, account for most of the valid variance, and Hypothesis 10 was tested to determine whether this proposed new composite did, in fact, constitute a significant improvement over the current Navigator-Technical composite.

Hypothesis 9 (that additional cognitive scales make no contribution to the proposed Navigator-Technical composite) was accepted (i.e., was not significant; other materials increased R from .38 to only .40); this suggests that proposed content selections for the revised composite are appropriate. Hypothesis 10, which was rejected, suggests that the proposed revised Navigator-Technical composite constitutes a highly significant improvement over the old composite (R increases from .11 to .38).

It was noted earlier that the validity coefficients from which the regression problems were computed are point-biserials (which assume that the criterion is a "true dichotomy" with no underlying continuum of ability). Maximum validity obtainable from such data with the pass/fail ratio obtained in this study is .60. If one assumes that the criterion, in fact, represents an underlying continuous range of abilities, the appropriate validity coefficients would be computed as biserials. Validity of the revised composite computed from biserial validities is .64. It is, of course, expected that in applied use there will be some shrinkage in composite validity. When the shrinkage formula was applied to the .64 validity, it reduced to .63. It should also be noted that there is some attenuation in the correlations in this study due to range restriction on the current Navigator-Technical composite. On balance, it is expected that, in applied use, the revised Navigator-Technical composite will show very appreciable improvement in validity over the current composite.

IV. RECOMMENDATIONS

It is recommended that the AFOQT's revised Navigator-Technical composite consist of Scale Reading, Table Reading, Mechanical Principles, Block Counting, Electrical Maze, Rotated Blocks, Tools, in addition to General Science, Quantitative, and Aerial Landmarks subtests from the earlier version of the battery. Based on data from this study, these revisions have been accomplished for AFOQT, Form N.

It is also recommended that systematic follow-up validation of the revised Navigator-Technical composite be conducted to confirm that it is functioning as predicted in application.

As a laboratory effort, it is recommended that development of a noncognitive component for inclusion in future revisions of the Navigator-Technical composite be pursued. It is anticipated that the Personality Research Form will provide the most appropriate starting point for such effort; once developed, the scale should be carefully evaluated in an operational context before final implementation recommendations are made.

Table 1. **Means, Standard Deviations, and Validity Coefficients (N = 507)**

Variable	Mean	SD	Validity[a]
Strong Vocational Interest Blank (SVIB)			
1. Navy	3.37	8.78	.24**
2. Navigator	10.04	13.50	.01
3. Accountant	−5.24	8.99	.01
4. Academic Achievement	9.10	11.05	−.01
5. Architect	21.17	17.74	−.16*
6. Air Force Officer	−8.83	21.68	−.02
7. Senior CPA	2.90	8.80	.13
8. Computer Programmer	15.56	8.78	.14
9. Engineer	−4.23	16.59	.03
10. Masculinity−Femininity	2.46	15.61	.14
11. Math−Science Teacher	.57	10.28	.09
12. Mathematician	−15.83	20.42	−.01
13. Mortician	−17.30	11.26	−.11
14. Physicist	−7.90	22.82	.02
15. Specialization Level	5.35	5.67	−.03
16. Occupational Introversion−Extroversion	−23.08	20.74	.07
Officer Biographical and Attitudinal Survey (OBAS)			
17. Satisfaction	57.98	39.02	−.01
18. Motivation	74.11	26.79	−.06
19. Contract	32.57	25.46	−.03
State-Trait Anxiety Inventory (STAI)			
20. STAI-X2	31.00	6.81	−.06
Personality Research Form (PRF)			
21. Abasement	6.79	2.56	−.01
22. Achievement	15.17	2.93	.13
23. Affiliation	15.96	2.84	.07
24. Aggression	4.94	2.69	−.02
25. Autonomy	7.70	3.03	.05
26. Change	12.08	2.75	.12
27. Cognitive Structure	12.79	3.16	−.04
28. Defendence	7.40	2.77	−.10
29. Dominance	14.02	3.45	.18*
30. Endurance	14.58	3.23	.11
31. Exhibition	11.34	3.77	−.05
32. Harmavoidance	6.83	3.48	−.23**
33. Impulsivity	8.03	3.12	.03
34. Nurturance	14.79	2.90	−.03
35. Order	13.46	3.92	.05
36. Play	10.87	3.19	.08
37. Sentience	16.67	2.65	.21**
38. Social Recognition	11.53	3.14	−.05
39. Succorance	7.87	2.84	−.17*
40. Understanding	13.94	2.96	−.02
41. Infrequency	1.65	1.35	−.17*
42. Desirability	17.63	2.32	.14
Navigator Attitudinal Reference Battery (NARB)			
43. Military Attitude	15.12	5.27	.13
44. Career Attitude	11.73	5.58	.00
45. Satisfaction	23.40	9.94	−.14

Table 1 (*Continued*)

Variable	Mean	SD	Validity[a]
Reference Battery (Experimental Scales)			
46. Table Reading	25.14	7.08	.43**
47. Scale Reading	17.08	4.50	.55**
48. Letter Sets	19.65	4.67	.40**
49. Tool Functions	6.49	2.12	.23**
50. Electrical Information	6.78	1.94	.18*
51. Mechanical Principles	7.85	2.12	.35**
52. Word Knowledge	8.67	1.35	.19**
53. Word Grouping	8.00	1.55	.27**
54. Verbal Analogies	8.37	1.68	.34**
55. Block Counting	34.24	10.78	.39**
56. Point Distance	24.42	10.22	.20**
57. Electrical Maze	7.81	4.27	.30**
58. Pattern Detail	7.57	3.39	.15*
59. Rotated Blocks	6.26	2.33	.35**
60. Tools	6.79	2.04	.11
61. Figure Analogies	7.67	1.98	.38**
62. Hidden Figures	5.13	2.95	.26**
Air Force Officer Qualifying Test (AFOQT)			
63. Officer Quality Composite	58.34	27.49	.18*
64. Pilot Composite	64.13	24.96	.14
65. Navigator-Technical Composite	65.21	24.43	.19*
66. Verbal Composite	45.84	25.16	.15*
67. Quantitative Composite	37.89	25.38	.28**
Criterion			
68. Pass/Fail	.88	.33	–

[a]Not corrected for restriction in range. Validity coefficients are computed as biserials. Significance was evaluated in terms of mean differences for Pass vs. Fail cases.

*Significant at the .05 level.

**Significant at the .01 level.

Table 2. **Summary of Validities for UNT Pass/Fail (N = 507)**

	Nr. of Scales	Low Validity	High Validity	Median Validity
Cognitive Tests				
AFOQT Composites	5	.14	.28	.18
Experimental Scales	17	.11	.55	.30
Noncognitive Tests				
Strong Vocational Interest Blank	16	−.11	.24	.02
Personality Research Form	22	−.23	.21	.01
Officer Biographical and Attitudinal Survey	3	−.06	−.01	−.03
Navigator Attitudinal Reference Battery	3	−.14	.13	.00
State-Trait Anxiety Inventory	1	–	–	−.06

Table 3. **Prediction Models**

Model	Predictors[a]	Nr. of Predictors	R[b]
A	NT	1	.11
B	AFOQT	5	.19
C	AFOQT, STAI, NARB, PRF	30	.36
D	AFOQT, OBAS, SVIB	22	.28
E	AFOQT, RB	22	.40
F	AFOQT, RB, SVIB	37	.42
G	AFOQT, RB, OBAS	25	.40
H	AFOQT, RB, PRF	41	.46
I	AFOQT, RB, NARB	25	.41
J	Quantitative Composite, Navigator-Technical Composite, Scale Reading, Mechanical Principles, Block Counting, Electrical Maze, Rotated Blocks, Tools, Table Reading	9	.38

[a]The following abbreviations are used:
NT = Navigator-Technical composite from AFOQT.
AFOQT = The five AFOQT composites.
STAI = State-Trait Anxiety Inventory (1 scale).
NARB = Navigator Attitudinal Reference Battery (3 scales).
PRF = Personality Research Form (22 scales).
OBAS = Officer Biographical and Attitudinal Survey (3 scales).
SVIB = Strong Vocational Interest Blank (16 scales).
RB = Reference Battery (17 scales).

[b]Data on which these R's are based are not corrected for range restriction. Criterion r's used in the regression computations are point-biserials.

Table 4. **Hypotheses**

In Prediction of UNT Success	cf Regressions[a]
1. Other AFOQT material adds nothing to Navigator-Technical	B and A
2. STAI, NARB, and PRF add nothing to AFOQT	C and B
3. OBAS and SVIB add nothing to AFOQT	D and B
4. Experimental cognitive tests add nothing to AFOQT	E and B
5. SVIB adds nothing to AFOQT and the experimental cognitive tests	F and E
6. OBAS adds nothing to AFOQT and the experimental cognitive tests	G and E
7. PRF adds nothing to AFOQT and the experimental cognitive tests	H and E
8. NARB adds nothing to AFOQT and the experimental cognitive tests	I and E
9. Other portions of AFOQT and the experimental cognitive tests add nothing to the proposed new Navigator-Technical composite	E and J
10. Proposed new Navigator-Technical composite adds nothing to the current Navigator-Technical composite	J and A

[a]From Table 3.

Table 5. **Summary of Hypothesis Test Results**

Hypothesis	df_1	df_2	F Ratio	Significance Level
1	4	501	2.79	.05
2	25	476	2.04	.01
3	17	484	1.29	NS[a]
4	17	484	4.15	.01
5	15	469	.89	NS
6	3	481	.53	NS
7	19	465	1.66	.05
8	3	481	1.73	NS
9	13	484	.50	NS
10	8	497	9.68	.01

[a]Not Significant.

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APPENDIX A: DESCRIPTION OF TESTS

The 62 experimental variables[1] are described below:

Noncognitive Scores

Strong Vocational Interest Blank (SVIB). This is a well-known commercial interest test. The test consists of 400 "items" (jobs, pastimes, activities, characteristics of people, etc.). The subject responds to each of these by indicating whether he/she likes, dislikes, or is indifferent to the activity or characteristic presented in the item. Numerous occupational interest keys have been developed by comparing responses of individuals in a specific occupation with responses of "men-in-general" and keying responses which distinguish incumbents from the "men-in-general" group. Sixteen SVIB keys used in this study were:

(1) Navy
(2) Navigator
(3) Accountant
(4) Academic Achievement
(5) Architect
(6) Air Force Officer
(7) Senior CPA
(8) Computer Programmer
(9) Engineer
(10) Masculinity-Femininity
(11) Math-Science Teacher
(12) Mathematician
(13) Mortician
(14) Physicist
(15) Specialization Level
(16) Occupational Introversion-Extroversion

Officer Biographical and Attitudinal Survey (OBAS). This instrument is a survey of background items and attitudes toward various facets of military life. It was constructed by the Personnel Research Division, AFHRL. The OBAS yields three scores, all of which were used in this study.

(17) Satisfaction
(18) Motivation
(19) Contract

(20) *State-Trait Anxiety Inventory (STAI).* This instrument is a list of questions which ask the subject about his anxiety at the moment he is taking the test (STAI-XI) and about his usual level of anxiety (STAI-X2). The instrument was developed by Spielberger, Gorsuch, and Lushene, and is published by Consulting Psychologists Press. In this study, only the STAI-X2 score was used.

Personality Research Form-Form AA (PRF). This is a survey-type personality inventory of 440 questions, authored by Douglas Jackson and published by Research Psychologists Press, Inc. It yields 22 scores for personality dimensions. All 22 of these were included in this study. They are:

(21) Abasement
(22) Achievement
(23) Affiliation
(24) Aggression
(25) Autonomy
(26) Change
(27) Cognitive Structure
(28) Defendence
(29) Dominance
(30) Endurance
(31) Exhibition
(32) Harmavoidance
(33) Impulsivity
(34) Nurturance
(35) Order
(36) Play
(37) Sentience
(38) Social Recognition
(39) Succorance
(40) Understanding
(41) Infrequency
(42) Desirability

Navigator Attitudinal Reference Battery (NARB). This survey, developed at AFHRL, consists of 75 questions about attitudes judged relevant to Navigator training success. It yields three scores:

(43) Military Attitude
(44) Career Attitude
(45) Satisfaction

The Reference Battery. This is a battery developed by the Air Force Human Resources Laboratory for use in various experimental test development studies. Subtests used from this battery are:

[1] In addition to the 62 variables treated in this report, a subsample of 77 cases was administered a battery of perceptual/psychomotor tests. These data are treated in a separate report (Hunter et al., 1977) under work unit 77191505.

(46) *Table Reading.* A speed test of ability to correctly read tabled values given table row and column designators.

(47) *Scale Reading.* A speed test of ability to render accurate readings from a pointer on various scales.

(48) *Letter Sets.* In each item, the subject is presented with five sets of four letters. Four of these five sets follow some general principle. The subject is to indicate which set does not follow the principle common to the other four.

(49) *Tool Functions.* Tests knowledge of simple shop activities. Subject is presented drawings of shop tools and activities and is asked questions based on them.

(50) *Electrical Information.* Tests understanding of basic electrical principles.

(51) *Mechanical Principles.* Questions are based on drawings of mechanical devices and are designed to test comprehension of the principles involved in their operation.

(52) *Word Knowledge.* A vocabulary test. The subject must select the one of five alternatives which most nearly means the same thing as a stem word.

(53) *Word Grouping.* Subject must find which of five words does not belong logically with the others.

(54) *Verbal Analogies.* A typical verbal analogies test. Subject must select the alternative bearing the same relation to the first word of a pair as that between a complete pair stated in the stem.

(55) *Block Counting.* Subject is presented with drawings of stacks of blocks. He must indicate how many other blocks a designated block is touching.

(56) *Point Distance.* The subject is given a reference point and two other points, "A" and "B." He is to indicate whether "A" or "B" is closer to the reference point. Distracting lines, designs, and patterns are interposed.

(57) *Electrical Maze.* A maze test, with electrical wires, connectors, and boxes comprising the maze. Subject must identify which one of the five possible circuits is complete.

(58) *Pattern Detail.* Subject is given a short time period to study minutely five abstract patterns. Then he must turn the page and pick each pattern out of five similar ones differing only in small details. He is not permitted to turn back.

(59) *Rotated Blocks.* Subject must visualize how a given irregular block will look when rotated in various ways and pick it from among five alternatives.

(60) *Tools.* A picture of a tool is presented to subject. He must pick out of four alternative pictures the tool or material most frequently used with it.

(61) *Figure Analogies.* A standard figure analogies test. Subject is presented with geometric figure X which has been changed in some way to make another figure Y. He is also given Figure Z which must be changed analogously. Subject must find among five alternatives what Z will look like after appropriate changes.

(62) *Hidden Figures.* A complicated geometric design is presented. Subject must choose which one of five simpler designs is imbedded.

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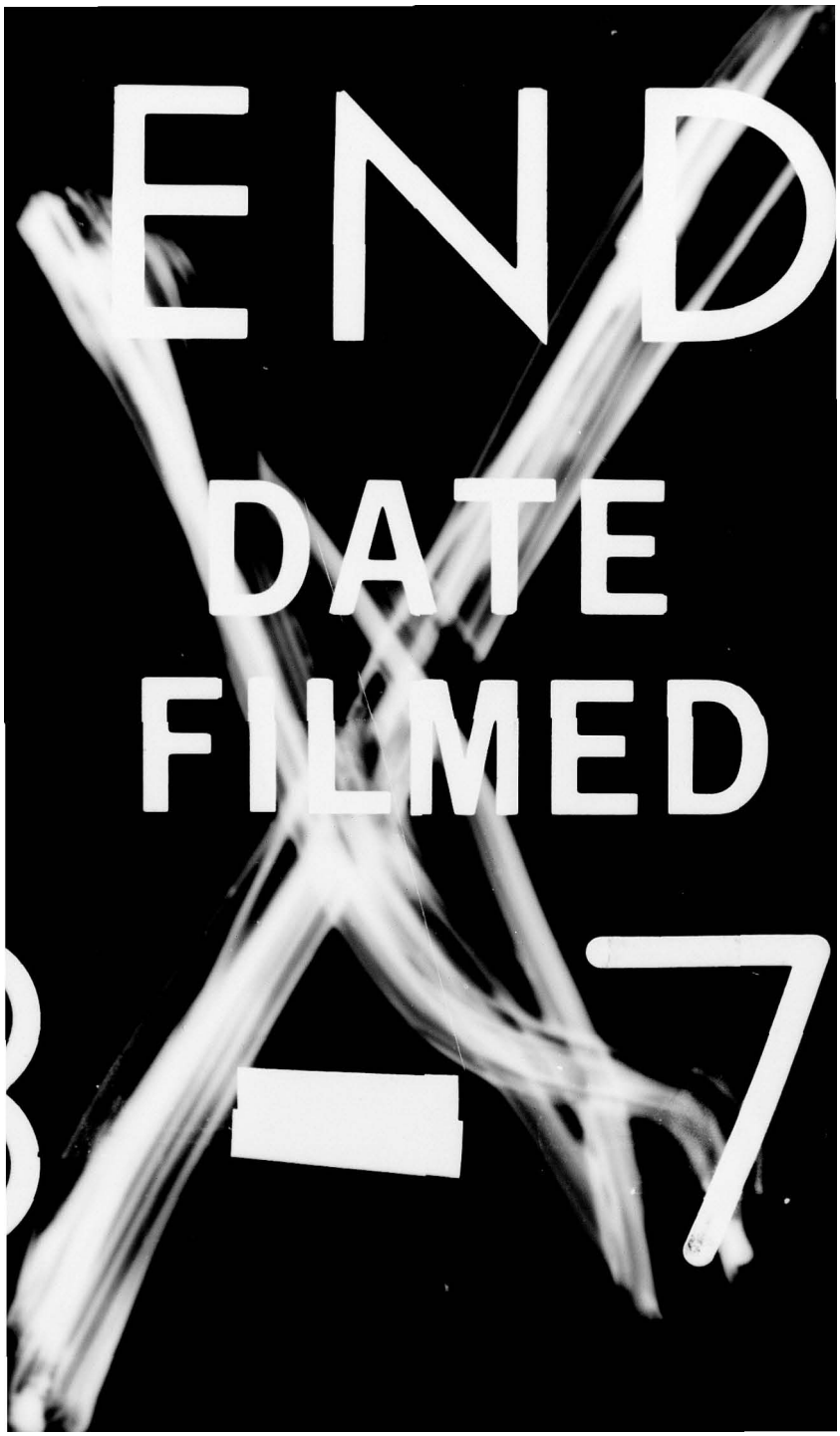
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Errata

Number	First Author	Title
AFHRL-TR-73-19 (AD-775 714)	Guinn	Effect of an All-Volunteer Force on Input into the School of Military Sciences, Officer Training Program
AFHRL-TR-76-9 (AD-A025 851)	Guinn	Background and Interest Measures as Predictors of Success in Undergraduate Pilot Training
AD-A042689 AFHRL-TR-77-36 (AD-A042 689)	Valentine	Navigator-Observer Selection Research: Development of New Air Force Officer Qualifying Test Navigator-Technical Composite
AFHRL-TR-78-33 (AD-A058 418)	Hunter	Pilot Selection System Development

Due to scoring errors which were found in the data files of the Air Force Officer Qualification Test — Forms L, M, and N, all analyses using aptitude scores derived from these test forms which are contained in the subject technical reports above are considered erroneous.

NANCY GUINN, Technical Director
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